Life Sciences Division **June 1, 1998**

Space Life Sciences

Standard Companion Document

1998

A Companion Document
to
Agency Solicitations
in
Space Life Sciences

Issued by the International Space Life Sciences Working Group

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Introduction

This supplement is a companion to 1998 research solicitations released by agency members of the International Space Life Sciences Working Group: United States (National Aeronautics and Space Administration , NASA), the European Space Agency (ESA), and the space agencies of Canada (Canadian Space Agency, CSA), France (Centre National d'Ètudes Spatiales, CNES), Germany (Deutsches Zentrum für Luft-und Raumfahrt, DLR), and Japan (National Space Development Agency of Japan, NASDA). The various sections of this supplement provide a common basis for proposal preparation and submission by any eligible scientist, regardless of the country of origin.

Interested persons who do not have a copy of the appropriate agency research solicitation should contact one of the following persons for more information:

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Proposers submitting responses to agency solicitations should be aware that the proposal submission deadline for 1998 is **October 1, 1998**.

1.0 Space Life Sciences Proposal Evaluation Process

This section describes the evaluation and selection processes that will be used for funding proposals submitted to any member agency of the International Space Life Sciences Working Group (ISLSWG) in reply to 1998 research solicitations.

Each research proposal must be a complete response to the appropriate individual space agency's official solicitation. In that solicitation, an agency may define a number of critical constraints that proposals must satisfy to be considered for selection. For example, an agency may fund no work in certain discipline areas, or no work without a flight component. Proposals to these agencies to carry out work that will not be funded by them will be returned to the proposer immediately following submission. For this reason, proposers are advised to communicate with their agency officials prior to submission if there is any doubt of the acceptability of a proposal by the agency in question.

The overall review process for each proposal will include the following factors:

- Intrinsic scientific or technical merit
- Flight feasibility (flight experiments only)
- Relevance to the programs of the soliciting agencies
- Cost (applicable to proposals submitted to NASA and CSA only)

The most important factor in the evaluation is intrinsic scientific or technical merit, followed by flight feasibility, relevance to agency programs, and cost (if applicable). Compliant proposals will undergo a three-tiered review process to assess these factors.

1.1 Merit Review

The first review tier will be a merit review by a panel of international scientific or technical experts. The number and diversity of experts required will be determined by the response to the research solicitations and by the variety of disciplines represented in the proposals, relevant to each agency's research emphases. In general, experts will be drawn from the international scientific community. All panels will utilize the same factors in their evaluation and all panel meetings will be conducted using the same review guidelines. The merit review panel will assign ***a score from 0-100*** or a score of "not recommended for further consideration," based upon the intrinsic scientific or technical merit of the proposal. This score will reflect the consensus of the panel.

The score assigned by this panel ***will not be affected by the cost of the proposed work or reflect the programmatic relevance of the proposed work to the sponsoring agency***. However, the panel will be asked to include, in their critique of each proposal, any comments they may have concerning the proposal's budget and relevance to the agencies.

The following will be used in determining the merit score:

Significance: Does this study address an important problem? If the aims of the application are achieved, how will scientific knowledge or technology be advanced? What will be the effect of these studies on the concepts, methods, or products that drive this field?

Approach: Are the conceptual framework, design, methods, and analyses adequately developed, well integrated, and appropriate to the aims of the project? Is the proposed approach likely to yield the desired results? Does the applicant acknowledge potential problem areas and consider alternative tactics?

Innovation: Does the project employ novel concepts, approaches, or methods? Are the aims original and innovative? Does the project challenge existing paradigms or develop new methodologies or technologies?

Investigator: Is the investigator appropriately trained and well suited to carry out this work? Is the work proposed appropriate to the experience level of the principal investigator and any co-investigators? Is the evidence of the investigator's productivity satisfactory?

Environment: Does the scientific environment in which the work will be performed contribute to the probability of success? Do the proposed experiments take advantage of unique features of the scientific environment or employ useful collaborative arrangements? Is there evidence of institutional support?

1.2 Flight Feasibility Review

The second tier of review, applicable only to flight experiment proposals, will be an evaluation of the feasibility of implementation of the proposed work on a space platform. This review will be conducted by an international team qualified to determine the feasibility of implementing the proposed projects using available flight and ground facilities.

The following criteria will be used in performing the flight feasibility review:

Functional Requirements: Will the available flight hardware meet the functional requirements of the experiment?

Space Platform Resource Requirements: To what extent will this experiment consume the launch vehicle capacity and flight platform resources (such as crew time and electrical power) that are projected to be available? Are sufficient resources available? Does this experiment require such a large amount of the available resources that it will preclude conduct of other experiments? Based on the required number of samples or subjects, can the experiment be carried out within a reasonable period of time?

Operational Impacts: For experiments that utilize the crew as research subjects, could the implementation of these experiments, even if considered safe, lead to an impact to the performance of the crew subjects?

1.3. Evaluation of Programmatic Relevance and Cost

The third tier of review will consider two factors: programmatic relevance and cost. This review will be conducted independently by program scientists and managers from each soliciting agency for proposals submitted to their specific solicitation. Programmatic relevance will include an evaluation of how the proposed work may help achieve an appropriate balance of scientific and technical tasks required by critical research issues faced by the soliciting agencies. Evaluation of cost will be performed for proposals submitted to NASA and CSA, or for proposals submitted to ESA that include a NASA or CSA component requiring funding from these agencies. Evaluation of the cost of a proposed effort includes consideration of the realism and reasonableness of the proposed cost and the relationship of the proposed cost to available funds.

1.4 Development of Selection Recommendation

The results of these three levels of review will in turn to prepare a **selection recommendation** developed by each of the soliciting agencies. This recommendation will be based on:

The numerical score for merit from the peer review panel.
The results of the flight feasibility review (if applicable).
The programmatic relevance and cost (if applicable).

The members of the ISLSWG will meet to discuss those issues related to appropriate coordination of agency selections to optimize science return and resource utilization. For example, the composite selection should not greatly exceed the projected flight opportunities. In addition, it may be more efficient or effective to form international teams of researchers to address overlapping questions and requiring similar, limited resources, than to have individuals competing for the use of the same specimens or test subjects. Experience has clearly shown that such teams are best formed at the time of selection, rather than later in the flight experiment development process.

Following this coordination meeting of the ISLSWG, each agency will finalize and announce its own selections.

Applicants should be aware that selection for flight is a multi-step process. Following the initial evaluation of flight proposals, a small group of investigators will receive a letter informing them that their experiment has been selected for definition. During the definition phase, the agency with jurisdiction over the investigator will interact with the applicant and determine whether the proposed experiment can actually be carried out on a space mission. At the end of this phase, a smaller group of investigators will be selected to be developed for flight. **Normally, full funding for the investigator does not begin until the initiation of the development phase.** Flight experiments selected will be reviewed every year and may be deselected based on the policy of each agency for deselection.

2.0 Flight Opportunities Available for Space Life Sciences

Proposals for space flight experiments for the time period between 2001 and 2003 may be submitted. All flight experiments must address one or more of the research programs and emphases defined in each agency's research solicitation.

It is expected that the majority of experiments selected will be performed on the International Space Station (ISS). A small number of opportunities may exist for short duration experiments that do not require ISS resources and can be accommodated in the middeck area of the Space Shuttle. Pre- and post-mission studies involving tests of the astronaut crew prior to and upon return from their space flight may also be submitted. Because this prospect is uncertain, proposals for research appropriate for ISS will have the highest priority for selection and funding.

The experiment opportunities are constrained in a number of ways; *Proposals requiring resources beyond the capabilities defined below should <u>NOT</u> be submitted.*

Potential applicants should recognize that, given the limited flight opportunities that are available, the flight experiments area is likely to be one of the most competitive arenas within space life sciences for 1998. It is preferred that flight experiment proposals represent mature studies strongly anchored in previous or current ground-based or flight research. Ground-based research may, and often must, represent one component of a flight experiment proposal. That research should be limited to activities that are essential for the final development of an experiment for flight, such as definition of flight protocols, and of ground control activities of the flight experiment. In this case, only one (flight) proposal need be submitted.

Applicants proposing flight experiments are **required** to provide the information requested on Form C (Section 6 of this Document). Flight experiment proposals should emphasize the actual experiment, duration requirements, and experiment conditions. The investigator should allow for flexibility in selecting the best hardware to be used to accomplish the experiment goals. Descriptions of the functional capabilities available to support human and non-human experiments are included in the Section 3 of this Document. Reference sources for information on specific hardware items are listed in Section 4.

Some investigators may wish to develop their own unique experiment hardware to work in conjunction with the facilities and functional capabilities described in this Document. Please keep in mind that the development of experiment-unique equipment will require additional funding and individual agencies may factor such cost negatively into their overall assessment. In the event that such items are proposed, they should be clearly identified as new developments. Proposals for major hardware items or facilities to be developed by the investigator will not be considered.

Flight experiments should be proposed as if the actual flight of the experiment will occur between 2001 and 2003. Experiments that cannot be initiated within this time period should not be submitted. Multiple flight opportunities may be provided in certain cases such as human experiments requiring a specific number of subjects. However, proposals requesting only one flight to meet their proposed research goals would have a higher probability of being accomplished. Informed consent of human subjects must be obtained prior to carrying out any study in space, and potential proposers should be aware that obtaining such informed consent will involve a uniform process regardless of the country of origin of the proposer.

2.1 Flight Experiments

2.1.1 ISS Flight Experiments

Research opportunities will be available during the construction phase of the International Space Station. The research will be accomplished during utilization flights when the Shuttle visits the ISS and during the time period between the utilization flights when the permanent onboard crew will act as experiment operators and, if necessary, as subjects. The duration of microgravity exposure during the 2001 to 2003 time period can, in theory, be indefinite with periodic disturbances every 30 days caused by U.S. and Russian transportation vehicle docking activities.

During the period of time covered by these solicitations, space life sciences research is restricted to utilize a limited hardware set. A list of the hardware is provided in Section 4 and the functional capabilities of this hardware are described in Section 3 of this Document.

It is expected that crew availability for science operations, power, and logistics resupply (frequency and mass to and from ISS) will be severely constrained throughout 2001 to 2003. The primary opportunities to transport scientific equipment, supplies, and samples will be on the utilization flights of the Shuttle; however, modest capabilities for research-related deliveries and sample returns will be available on assembly flights that will occur every 40 to 90 days. Refrigerated stowage for transport of samples on the Shuttle will be very limited, and during certain time frames, refrigerated stowage may not be available on the Space Station. Power outages may also be experienced during the assembly of ISS. Experiments with few or simple in-flight activities have the greatest potential for selection during this time frame due to their simpler logistic requirements.

2.1.2 Short Duration Flight Experiments

Short duration experiment proposals submitted in response to the research solicitations are restricted to experiments that can be accommodated on the Shuttle for approximately 11 days of microgravity exposure. The experiments themselves are usually stand-alone studies that require limited crew training and involvement to execute. In limited opportunities, it is possible to take advantage of the location in the Shuttle middeck to obtain late pre-flight installation and early post-flight retrieval of materials.

The number of crew subjects available to perform short duration human studies will be restricted due to the limited amount of crew time available for such experiments. The availability of Shuttle resources for experiments requiring animal subjects will also be extremely limited for short duration experiments. Experiments that do not require Orbiter power are accommodated more easily.

2.1.3 Potential Research Mission

As stated previously, it is possible that a Space Shuttle research mission may become available over the next couple of years. In the event that this becomes a reality, proposals submitted to these solicitations may be selected for such a mission.

2.2 Pre- and Post-Mission Studies

Opportunities will be available to perform experiments, collect samples, and take physiological measurements utilizing the astronaut crew both prior to their space mission and following their return to Earth. Such proposals are considered flight experiments and should specify the desired activities, the time frame in which these activities must be performed prior to and following the mission, and the required mission duration (e.g., prior to and following a short duration Shuttle mission versus a longer duration ISS mission).

3.0 Flight Research Capabilities

3.1 Research Involving Human Subjects

3.1.1 Physiological Monitoring

The ISS Human Research Facility (HRF) and the Space Shuttle and are outfitted with the medical equipment necessary to make a variety of physiological measurements. Most of these measurements may be made in conjunction with exercise equipment, or in combination with each other. Signal conditioning will be provided to amplify and process a variety of physiological signals and to provide a common interface for mating with associated experiment hardware.

Blood Pressure - The capability will be available to noninvasively monitor and collect blood pressure data, both continuous and intermittent, on human subjects. The data can be collected by manual or automated methods during periods of rest or exercise.

Electrical Stimulation of Muscle - Local noninvasive muscle stimulation on human subjects will be possible using a high current stimulator which provides trains of pulses up to 0.8 amps, according to pre-programmed protocols.

ECG / EMG / EEG - The capability will be available to acquire human physiological data such as ECG, EMG, EEG, temperature, and skin Galvanic response. Multichannel data (16 differential channels) can be collected by means of portable, crew-worn devices over extended periods of time (24 hours), or via rack-mounted devices.

Pulse / Blood Oxygen - A pulse oximeter will be available to continuously monitor the percentage of hemoglobin oxygen saturation in the blood.

Lung Volume - Respiration of crew members can be studied by continuously monitoring lung volume using respiratory impedance plethysmography.

Metabolic Activity - A mass spectrometer will be available to measure a subject's metabolic activity in the space environment. The mass spectrometer may be used in conjunction with other instrumentation for support of pulmonary function studies. The instrument may also be used with exercise equipment such as the strength measurement device or with aerobic exercise equipment such as the ergometer or treadmill.

Ultrasound / Doppler - An ultrasound system is available to perform medical imaging and to measure flow rates. The system uses hand-held probes and performs functions to support cardiac ultrasound, abdominal ultrasound (deep organ), vascular ultrasound, muscle and tendon ultrasound, transcranial ultrasound, and veterinary ultrasound.

Venous Occlusion Cuff and Controller (VOCC) - An inflatable venous occlusion cuff system for the subject's thigh or arm allows for the control of parameters such as time between inflations and inflation pressure.

3.1.2 Sample Collection and Stowage

Blood, urine, and saliva samples may be collected from crew subjects before, during, and after flight. Blood, urine, and saliva collection kits will be available for the collection, preservation, and storage of samples. Tracer kits will be available to provide oral ingestion, bolus-injection over a short period of time, or infusion over a designated period of time.

3.1.3 Exercise

There are two exercise devices available for research: a bicycle ergometer and a treadmill. The **Bicycle Ergometer** provides work load, driven by the hands or feet, that is controlled by manual adjustment or computer control. It operates with the subject seated or supine, and provides time-synchronized data compatible with other complementary analyses. The data output consists of work rates in watts and pedal speed (rpm) for use with a data acquisition system. The ranges are 25 to 350 watts +/- 5 percent (15 watt intervals) and 50 to 120 rpm (1 rpm intervals).

The **Treadmill** may be used for walking and running exercise. The device employs various strategies to simulate as closely as possible 1g skeletal loading during exercise bouts. The treadmill will measure and display the loads exerted on the subject by restraint harnesses prior to, during, and after the exercise bout. The Restraint System provides stabilization of the user, and load distribution on the body in a weightless environment. The treadmill can operate motor-driven (0 to 10 mph adjustable speed control with speed resolution of 0.5 mph) or passively (allows a subject to drive the tread at speeds ranging from 2 to 7 mph). The loads applied to the harness accelerating the runner towards the treadmill can be set between 40 lbs. and 220 lbs. with a load resolution of 5 lbs. As with the bicycle ergometer, the treadmill provides data compatible with other complementary analyses.

3.1.4 Measurement of Muscle Strength, Torque and Joint Angle

The following capabilities related to strength training and measurement will be available:

> Strength training and measurement of the torque generated during tests on the agonist and antagonist muscle groups of the trunk and extremity joints including ankle, knee, hip, wrist, elbow, shoulder, trunk, whole leg, and whole arm.
>
> Strength training and measurement of the strength during submaximal and maximal isometric, isokinetic concentric, and isotonic (concentric and eccentric) testing of the trunk, hip, and extremity joints listed below throughout the entire range of motion.
>
> Torque angular velocity measurements and training on the following joint movements:
> Knee flexion/extension
> Ankle flexion/extension
> Trunk flexion/extension
> Hip flexion/extension
> Shoulder flexion/extension; shoulder abduction/adduction; shoulder rotation.
> Elbow flexion/extension
> Wrist flexion/extension; supination/pronation; radial/ulnar deviation.

Display of peak torque vs. joint angles, and average torque at specific joint angles as well as torque-velocity throughout the entire range of motion.

Programming of variable and quantifiable velocities and resistances during training exercises.

Assessment of fatigue over serial contractions.

Measurement of hand grip strength or pinch strength as a function of time.

3.1.5 Cardiovascular Loading

A lower body negative pressure (LBNP) device that encloses the lower abdomen and lower extremities to maintain a controlled pressure differential below ambient during periods of extended weightlessness will be available. This device may be used in conjunction with the physiological monitoring capabilities described above. It will provide pressure applications to the lower body in a range from ambient to -60 mmHg. It allows performance of a continuous decompression to -60 mmHg, at the range from 10 seconds to 10 minutes (i.e., rapid decompression to slow decompression).

An adjustable foot support, removable saddle, and knee fixation within the device provides skeletal “loaded” and “unloaded” LBNP. The decompression device is available not only for cardiovascular research, but also for any other physiological research.

3.1.6 Activity

Measurements that are indicative of the crew’s activity level can be made using a small wrist- or ankle-worn device that can detect body movement. The device is used to evaluate sleep/wake adaptation, circadian cycles, sleep quality, sleep onset, hyperactivity, and other daily routines of human activity.

3.1.7 Posture

Measurement of joint angles (both lower and upper extremities; hip, knee, ankle, wrist, elbow, and shoulder) will be available to provide information critical for detailed analysis of changes in posture and mechanics of movement in space flight. Measurements may be made dynamically or at rest. Measurements may be made during exercise, in conjunction with torque/strength dynamometers, at workstations, and in motion studies. The capability will exist for in-flight, static and dynamic monitoring of:

Lower Extremity Angles:

- Hip / 2 Degrees of Freedom (DOF), specifically, flexion/extension, abduction/adduction
- Knee / 1 DOF, specifically, flexion/extension
- Ankle / 1 DOF specifically, plantar flexion and dorsi flexion

Upper Extremity Joint Angles:
- Wrist / 2 DOF, specifically flexion/extension and ulnar/radial deviation
- Elbow / 1 DOF, specifically flexion/extension
- Shoulder / 2 DOF, specifically flexion/extension and horizontal abduction/adduction.

Single axis loads between the foot and the supporting surface can be measured during any activity in which a crew member engages. In addition to the measurement of total force between the foot and the surface, regional force values may also be measured. Selective regional measurements of the loads applied to the rear-foot, mid-foot, medial metatarsal head, lateral metatarsal heads, hallux, and lesser toes can also be made.

3.1.8 Medical Procedures

It will be possible to deliver subcutaneous injections or infuse fluids intravenously. Approved substances may be orally ingested.

3.2 Research on Cells

It is possible to fly live cell cultures of various types for up to 30 days on orbit. Types of cultures that can be used include suspended and attached plant and animal cell cultures, animal tissue, bacterial cultures, and small, non-feeding aquatic organisms. Fresh cell cultures may be prepared from frozen cells transported to the ISS. Cell cultures of 3, 10, or 30 ml volume can be maintained within a temperature range of 4 to 40°C and an atmosphere with controlled humidity, temperature, pH, carbon dioxide, and oxygen levels. The cell images can be observed and evaluated by a phase-contrast/fluorescence microscope. The images may be transmitted to the ground laboratories when required. The experiment may be designed with simultaneous onboard reference samples under artificial gravity (0.1 to 2.0g) environment. Nutrients or special additives can be introduced into the culture media automatically, and waste products can be removed automatically to maintain a specific growing environment. In addition, fixatives may be introduced to terminate a study and prepare specimens for further analysis on the ground. Alternatively, specimens or the culture matrix may be sampled on orbit directly for further manipulation or storage. Simple cell manipulation essential for the experiment, such as solution mixing, DNA/RNA extraction, trypsinization, filtration, and concentration, may be carried out by a semi-automated method or by assistance of the crew. Videomicroscopy of either 40 or 200x, spectrophometry, and a phase-contrast/fluorescence microscope will be available. The culture chamber environment is sterile, and cells may be placed on the spacecraft just prior to launch.

3.3 Research Using Insects

Incubators, which can maintain temperatures ranging from 4 to 40°C, are available for research using insects. Insects can be housed within the incubators in petri dishes or similar containers. The larvae may be chemically fixated or frozen for analysis on the ground. Centrifugation of specimens is not possible with these incubators.

Centrifugation of specimens is available utilizing two similarly designed incubator-like units with small diameter centrifuge rotors. The first unit provides environmental control parameters (T: 18 to 40°C, RH: 50 to 90 percent, programmable light: 50W fluorescent, atmospheric control: O_2- 15 to 22 percent, CO_2- .03 to 5 percent). The centrifuge is 600 mm in diameter with variable accelerations up to 2g. The containers that can be centrifuged are up to 60 mm x 60 mm x 160 mm with the long axis in the g-vector. . Four containers are attached to each rotor platform. This unit also allows forced air flow of controlled composition through the container, water resupply, illumination, observation, and data acquisition inside the container.

Also available is an environmentally controlled unit (T: 15 to 30°C; RH: 20 to 80 percent; light: 0 to 20 microwatts/cm^2 selectable light cycle) that accommodates modular specimen containers in a microgravity rotor and concurrently in a selectable-gravity rotor from microgravity to 2g. The rotors are each 280 mm in diameter. The specimen container is designed specifically to allow investigators to study insects over multiple generations. Each specimen container (100 mm x 60 mm x 25 mm) supplies an adequate volume for nutrient medium to support developing eggs and larvae, as well as volume to support pupae, and adults for each generation. The habitat allows transferring of successive generations and the removal of individual insect containers for tissue preservation operations. A video camera system on each rotor can monitor individually selected specimen container. Video and environmental data will be recorded within the habitat and habitat holding rack, and can be downlinked to the ground as required.

The insects may be frozen or fixed on-orbit and/or returned to the ground alive for further studies.

3.4 Research Using Plants

During the time period for which these solicitations apply, plant research is limited to experiments with small specimens. The seeds or plants may be planted, grown, harvested, fixed, and stowed on orbit. The methods for performing those operations may be tailored to the needs of the investigator. Centrifugation (carrousel diameter up to 600 mm), temperature control, controlled air composition, water resupply, illumination, observation, and data acquisition are available in a variety of flight-certified hardware.

3.5 Research Using Aquatic Specimens

Experiments can be conducted using both freshwater and marine aquatic research models for periods of up to 30 days. A diversity of aquatic invertebrates can be accommodated as well as the early life-stages of vertebrate models such as zebrafish and medaka. The capability exists for egg fertilization under microgravity conditions, video observation of behavior and development, and automatic or manual on-orbit fixation of specimens.

Specialized syringe units will also make it possible to introduce experimental solutions to the specimen chambers.

The aquatic specimens can be studied in containers with volumes of up to 60 mm x 60 mm x 160 mm, and placed in incubators with temperature ranges of 10 to 40°C. Two different facilities are available for research. In one, the incubators are equipped with centrifuge rotors of 600 mm diameter, allowing accelerations between 0.001xg and 2.0xg. The atmosphere inside the containers can be controlled with respect to humidity, carbon dioxide, and oxygen concentration; trace gases can be removed. The containers are also provided with water resupply, illumination, observation, and power and data acquisition. The second facility is the size of a middeck locker and allows for centrifugation up to 1g. Storage of additional chamber units will be provided to temperatures as low as 6°C.

A middeck locker-size fresh water habitat module that allows for several weeks of controlled incubation of different specimens (e.g., *Xiphophorus helleri, Biomphalaria glabrata, Ceratophyllum spec*.) is available for research. The module is divided into an experiment module and a support module. The experiment module offers different compartments for adult and larval stages of fish and snails as well as plant material and the microbiological filter system with a total volume of approximately 8.5 l. The support module controls water flow, thermal condition, and illumination cycles (including O_2 dependent plant illumination), as well as monitoring and storage of different water parameters (temperature, pH, pO_2) and video recording. Water quality is maintained and regulated within the equilibrated biological aquatic system where every organism serves as an experimental object as well as an integral part of the life support system.

3.6 Research Using Quail Eggs

In mid 2000, a test will be conducted onboard ISS to validate the performance of the Avian Development Facility (ADF). Fertile quail eggs will be collected on the ground, chilled to arrest development, and launched within a few days. Once on orbit, the eggs will be incubated in microgravity for 14 to 16 days in the ADF. Fixation is automated and can be programmed to fix eggs at any time during incubation. While some of the specimens will be used to validate hardware by analyzing the fixed embryos at various stages of development, all of the unused tissues will be available for research. The current plan is to fix embryos at early (2 to 4 days), middle (6 to 8 days), and late (14 to 16 days) stages of development. This special incubator includes two internal centrifuge rotors which are capable of providing selectable gravity levels of up to 1.5g. In the proposed validation test, one rotor will maintain 1g and the other will remain stationary. The specimens are launched and returned in the Orbiter Middeck which allows late access prior to launch and early access to experiment hardware upon return.

The ADF will accommodate a total of 40 quail eggs. It is designed to regulate temperature to set points in the range of 26 to 40ºC ±0.5°C (37.8°C will be used as nominal incubation temperature for quail) during the incubation, and 10 - 18ºC during egg storage. Humidity will be regulated to set points in the range of 50 to 75 percent. The ADF also maintains oxygen at 21 percent and carbon dioxide levels to less than .03 percent. It provides for on-orbit fixation of individual eggs. Egg restraints are shock mounted and the ability to rotate the eggs is also available. Beyond this validation, the facility will accommodate other egg development specimens (e.g., chickens, turtles, etc.).

3.7 Research Using Rodents

Rodents, such as laboratory rats and mice, can be supported on orbit for up to 90 days. This capability allows for studies with rodents from post-weaning through adulthood. Video imaging of at least 90 percent of the cage volume for light cycle and dark cycle is provided. Temperature and humidity control, lighting intensity and photoperiod control, food and water delivery, and waste management for a number of either rat (up to 600 grams) or mouse (up to 60 grams) specimens are provided. Rats or mice may be either grouped or housed individually. The temperature is regulated to setpoints in the range of 20 to 27°C. The illumination range is selectable from 0 to 40 lux in approximately 10 lux increments with selectable photoperiods in six minute increments. An airflow rate of at least 10 changes per hour prevents the accumulation of carbon dioxide and ammonia. The research animals may be dissected on orbit and their parts chemically fixated or frozen for analysis on the ground.

3.8 General Support Capabilities

3.8.1 Thermal Control

A variety of refrigerators, freezers, and incubators will be available to support sample preservation on-orbit in the ISS and sample transportation on the Shuttle. The refrigerators will maintain samples at 4°C ± 2°C and the freezers will maintain samples at a nominal temperature of -80°C. The refrigerators and freezers will be transported powered during certain increments. A passive GN_2 freezer, housed in the Shuttle Middeck, will be used for limited transport of freezer samples during certain increments. It maintains samples below -180°C for the length of a Shuttle mission (up to 16 days). The incubators will maintain samples at set points between 4 and 45°C. Some incubators will be transported powered in the Shuttle Middeck.

3.8.2 Mass Measurement

The ISS will have the capability to measure the mass of the human body, live animal specimens, plants, solids, semi-solids, and liquids (in containers). The small mass measurement range will be from 1 g to 5 kg, and the micro mass range will be from 10 mg to 10 g.

3.8.3 Computers

A laptop computer outfitted with mass storage devices, communication adapters, power supplies and cables, and custom built software is available for use. It can operate software written for Microsoft Windows.

A computer workstation will be available that is capable of providing high capacity data collection and mass storage, display of high resolution graphics, video processing, and real time data processing. The workstation will be compatible with a wide variety of operating systems including DOS/Windows, UNIX/X-windows, OS/2, Windows NT, and Mac OS. The workstation will also be capable of uploading and downloading software and data and be capable of multichannel equal interval sampling and precise reaction time measurement.

3.8.4 Radiation Monitoring

A passive dosimeter system will be available on the ISS to determine the space radiation dose for payloads at specific locations within ISS. It uses thermoluminescent detectors (TLDs) to accumulate dose, and a reader/annealer to measure that dose on-orbit. TLD sensitivity varies depending on the energy spectrum of the space radiation present. Therefore, it is necessary to use plastic nuclear track detectors (PNTDs) to determine the energy spectrum of the radiation absorbed by the TLDs. The PNTDs are co-located with TLDs during dose accumulation. The PNTDs are returned to the ground and are processed and analyzed in a laboratory to obtain the linear energy transfer (LET) spectrum. The LET spectrum is then combined with the dose information from the TLDs to determine a corrected total dose. This system can provide dose information for periods as short as 10 minutes or as long as one year.

Two active dosimeter systems will be available on ISS: a tissue equivalent proportional counter (TEPC) and a charged particle directional spectrometer (CPDS). The TEPC will be moved around the pressurized volume of ISS in the first few months of operation in order to map out the radiation environment. It will eventually be based in the Hab Module, but will continue to be used for periodic surveys of the various modules, in order to capture the effects of adding more modules onto the vehicle as well as solar cycle modulation of the radiation environment. This instrument has the capability for real time data collection and viewing.

The CPDS will also have limited real time data collection capability. There are two CPDSs. One will be housed inside the Hab Module and the other, a triple CPDS with 3-axis sensitivity, will be located outside on the S0 truss. The intravehicular CPDS will also be moved from module to module to conduct surveys. Initially, the instruments' first priority will be to support operational measurements, including contingencies. Eventually, the data expected to become available for payload users.

3.8.5 Video Imaging

We will have the capability of documenting ISS activities using video and still cameras. Formats will probably be 35mm (are positive and negative) and 8mm camcorder.

3.8.6 Centrifuges

In addition to the centrifuges that are built into various habitats and facilities, there are smaller centrifuges available for separation of biological samples such as blood and saliva.

3.8.7 Gloveboxes

Gloveboxes provide an enclosed environment to conduct manipulations of specimen, chambers, materials, and science support equipment necessary to conduct experiments in orbit. These gloveboxes have been designed to isolate the crew from potential hazardous materials used during experiment operations such as fixations, injections, waste removal, and dissections while maintaining an internal environment suitable for specimen manipulation.

4.0 Flight Hardware

The following tables provide listings of hardware available for space research, the earliest availability of each hardware item, and the space agency responsible for the development of the hardware. Detailed information on this hardware is available at the following Internet address:

http://peer1.idi.usra.edu/peer_review/nra/spec_res_fac.html

Table 4.1 Hardware Available to Support Human Subject Research	Earliest Availability	Short Duration	Long Duration	Agency
Physiological Monitoring				
Manual Blood Pressure Device	1998	X		NASA
Automatic Blood Pressure System	1998	X		NASA
Continuous Blood Pressure Device	1999		X	NASA
Combined Blood Pressure Monitoring	1999		X	NASA
Percutaneous Electrical Muscle Stimulator	1999	X	X	NASA/ESA
Gas Analyzer Mass Spectrometer	1999		X	NASA
ECG / EMG / EEG	1999	X	X	NASA
Pulse Oximeter	1998	X	X	NASA
Respiratory Impedance Plethysmograph	1998	X	X	NASA
Ultrasound Doppler	1999		X	NASA
Venous Occlusion Cuff and Controller	1998	X		NASA
Sample Collection and Stowage				
Human Sample Collection Kits	1998	X	X	NASA
Exercise				
Bicycle Ergometer	1998	X	X	NASA
Treadmill	1998	X	X	NASA
Strength Training and Measurement				
Muscle Atrophy Research and Exercise System	1999		X	NASA/ESA
Resistive Exercise Device	1999		X	NASA
Hand Grip/Pinch Force Dynamometer	1998	X	X	NASA/ESA
Cardiovascular Loading				
Lower Body Negative Pressure	1999	X	X	DLR
Activity				
Activity Monitor	1999		X	NASA
Posture				
Foot-Ground Interface	1999		X	NASA
Range of Motion Suit (Goniometers)	1999		X	NASA
Medical Procedures				
Injection and Infusion System	1998	X	X	NASA

Table 4.2 Hardware Available to Support Non-Human Subject Research	Earliest Availability	Short Duration	Long Duration	Agency
Research on Cells				
Cell Culture Module	1998	X	X	NASA
DLR SIMPLEX	2000	X	X	DLR
Biopack	2000		X	ESA
Cell Culture Unit	2001		X	NASA
Cell Biology Experiment Facility	2001		X	NASDA
Biolab	2002		X	ESA
Research on Insects				
Biological Research in Canisters (BRIC)	1998	X	X	NASA
Biopack	2000		X	ESA
Modular Cultivation System	2001		X	ESA
Insect Habitat	2001		X	CSA
Biolab	2002		X	ESA
Research on Plants				
Biological Research in Canisters (BRIC)	1998	X	X	NASA
Biopack	2000		X	ESA
Cell Culture Unit (plant cell culture only)	2001		X	NASA
Modular Cultivation System	2001		X	ESA
Biolab	2002		X	ESA
Research on Aquatic Specimens				
Aquatic Research Facility	1998	X		CSA
CEBAS	1998	X	X	DLR
Biopack	2000		X	ESA
Cell Culture Unit (non-feeding only)	2001		X	NASA
Modular Cultivation System	2001		X	ESA
Biolab	2002		X	ESA
Research using Quail Eggs				
Avian Development Facility	1999		X	NASA
Research using Rodents				
Animal Enclosure Module	1998	X		NASA
Advanced Animal Habitat	2002		X	NASA

Table 4.3 General Purpose Research Support Hardware	Earliest Availability	Short Duration	Long Duration	Agency
Thermal Control				
Incubators	1998	X	X	NASA
Passive Freezers	1999		X	NASA
Minus Eighty Degree Life Sciences Freezer	2000		X	NASA/ESA
GN_2 Freezers	1998	X		NASA
Mass Measurement				
Small Mass Measurement Device	2002		X	NASA
Body Mass Measurement Device	1999		X	NASA
Micro Mass Measurement Device	2002		X	NASA
Computers				
Laptops	1998	X	X	NASA
Human Research Facility Computer Workstation	1999		X	NASA
Radiation Monitoring Tools				
Tissue Equivalent Proportional Counter	1998	X	X	NASA
Charged Particle Directional Spectrometer	1998	X	X	NASA
Passive Dosimeters	1998	X	X	NASA
Realtime Radiation Monitoring Device	2001		X	NASDA
Video Imaging	1998	X	X	Various
Centrifuges				
Hematocrit Centrifuge	1998	X	X	NASA
HRF Centrifuge	1999		X	NASA
Orbiter Centrifuge	1998	X		NASA
Refrigerated Centrifuge	1999		X	NASA
Gloveboxes				
Life Sciences Glove Box	2001		X	NASA
Clean Bench	2001		X	NASDA
Microscopes				
Compound Microscope	2001	X	X	NASA
Dissecting Microscope	2001	X	X	NASA

5.0 Special Ground Research Facilities

This section provides descriptions of special research facilities currently available for use by the international scientific community. These facilities are available to investigators for ground research at sites specified in the description. Applicants should contact the person(s) identified at the end of each facility's description for additional scientific and technical information. Applicants are cautioned that the cost of using these facilities, and the cost of travel to and from the facilities, **must** be included in any proposal requiring them. Facility use costs **must** be negotiated and approved by the listed contact person **prior** to proposal submission.

5.1 Research Facilities in the United States

5.1.1 The Vestibular Research Facility (VRF)

The Vestibular Research Facility (VRF) at the NASA Ames Research Center (ARC) provides unique, state-of-the-art equipment for ground-based studies of the effects of precise low-noise angular and linear accelerations on biological subjects. The VRF houses the following:

- Multi-Axis Centrifuge
- 12' Linear Spring Sled
- 30' Human-Rated Sled
- Programmable Linear Sled

VRF hardware enables the study of responses to smooth, linear motion or to combinations of linear and angular motion over the frequency range of natural head movement. Specific space-related and non-space-related science questions may be addressed. The facility permits electrophysiological study of how complex linear or rotational accelerations are transduced during centrifugation, encoded by biological sensors, and processed by the brain. Interactions between linear and angular motion, as well as visual and proprioceptive inputs (peripheral, central, and motor) may be examined in any physiological system using electro-physiological, reflex, and behavioral methods. Sensorimotor interactions under complex linear and angular acceleration conditions may be studied systematically.

The VRF Multi-Axis Centrifuge allows an investigator to apply up to 2g linear (centrifugal) acceleration to a gimbaled Specimen Test Container (STC) whose center is at a 1.0 meter radius from the centrifuge's axis of rotation. Gimbal motors allow an experimenter to apply DC to 5 Hz angular motions (up to 500º/sec velocity and $500º/sec^2$ acceleration) to the STC and its 54 pound payload during centrifugation. Fifteen electrically isolated slip-ring assemblies allow the recording of multiple channels of electrophysiological data continuously during centrifugation. This centrifuge accommodates small primates and rodents or smaller animal or plant specimens.

The VRF 12' Linear Spring Sled is a 12-foot granite track with a movable carriage supported on air bearings that allow the delivery of low-noise (<10^{-3} g's) oscillatory linear acceleration (0.25Hz, 0.20g pk, 0.50, 1.5, and 5.0 Hz, 0.354g pk) to carriage payloads of up to 1200 pounds. Experimental hardware is available for studies in rodents, birds, and primates. This sled has been used for studies of electrophysiological responses of neurons and reflex responses to linear acceleration.

The VRF 30' Linear Sled also uses air bearings to produce noise-free linear acceleration for studies of human perception of linear acceleration that do not confound vestibular cues with somatosensory ones. It also enables other physiological studies of humans and other species. The long track enables lower stimulus frequencies (periodic motion from 0.25 to 5.0 Hz at 0.5g peak), and noise-free periods of constant linear velocity (trapezoidal profiles with acceleration and deceleration of 1.0g, and 100 cm/sec constant velocities). It consists of an experimental platform floating on air bearings on a granite surface. A gimbaled chair is mounted on the platform to accommodate human subjects or the specimen container from the 12 foot sled for non-human subjects. Solid support is provided by a 30-foot long block of granite. The 30' linear sled can accommodate humans, small primates, rodents, small chicks, or other biological specimens.

A Programmable Linear Sled (PLS) uses air-bearings and new linear motor technology to study vestibular system responses in small primates, rodents, or smaller animal specimens. This device allows studies of electrophysiological, reflex, or behavioral responses in animal subjects up to the size of a small primate during precisely controlled linear oscillations (1.0 to 5.0 Hz, $\pm$1g peak acceleration) parallel to or perpendicular to Earth gravity (i.e., horizontally or vertically). The PLS supports short-term studies of biological responses to linear acceleration.

For details regarding scientific capabilities of VRF devices, contact the VRF Science Director at Ames Research Center at 650-604-5723. For technical details and scheduling information, contact the Facility Utilization Office Manager at Ames Research Center. Telephone: 650-604-6483.

5.1.2 Human-Rated Hypergravity Facilities

The NASA Ames Research Center has two hypergravity facilities that enable psychophysical and physiological research on humans and other species. They are:

- 20-g Human-Rated Centrifuge
- Human Powered Centrifuge.

In addition, a third facility, the Chronic Live-Aboard Exposure (52' Diameter) Centrifuge is being renovated to support chronic human, animal, and plant studies under hyper-gravity forces up to 2g.

The 20-g Human-Rated Centrifuge, NASA's only centrifuge currently human-rated (to 12.5g), enables delivery of accelerations with onset rates of 1 g/sec to 12g and 0.5 g/sec from 12 to 20g. It has three enclosed cabs, each with a 16,000 g-pound payload capacity. One cab, with a 29-foot radius, contains a modified jet fighter ejection seat in which a human volunteer sits during psychophysical or physiological tests. A second cab, located at the other end of the rotating arm, can be configured to meet other needs, including simulating Space Shuttle launch and landing profiles in humans, rodents, other animal or plant species, or in cell cultures. A third cab, located near the center of the centrifuge rotation can also be adapted to experimental requirements. This cab allows investigators to study variable gravity gradients and can also be used as an on-center control for angular acceleration. Hypergravity exposures of minutes to hours may be used.

For details regarding scientific capabilities of this device, contact the 20-g Human-Rated Centrifuge Science Director at Ames Research Center at 650-604-6441. For technical details and scheduling information, contact the Facility Utilization Office Manager at Ames Research Center. Telephone: 650-604-6483.

The Human Powered Centrifuge is a 6.25-foot radius centrifuge. A recumbent bicycle provides onboard power for rotation of from minutes to hours, allowing human-generated gravitational forces to a payload of up to 500 pounds, with or without exercise. Human subjects have been found to be capable of generating up to 5 g's of acceleration comfortably, reaching maximum rotation speeds of 50 rpm. Electronic equipment for monitoring physiological parameters, such as cardiovascular function, temperature oxygen consumption, and other basic data, may be mounted onboard, or with signals taken off through slip rings.

For details regarding scientific capabilities of this device, contact the Human-Powered Centrifuge Science Director at Ames Research Center at 650-604-6604. For technical details and scheduling information, contact the Facility Utilization Office Manager at Ames Research Center. Telephone: 650-604-6483.

The Chronic Live-Aboard Exposure (52' Diameter) Centrifuge, originally designed to enable hyper-gravity research only on animals, is being upgraded to support chronic human, animal, and plant studies under gravity forces up to 2g for periods of weeks to months. This facility will allow experimenters to live and work onboard a centrifuge to explore physiological and behavioral questions about chronic adaptation to altered gravity in humans and in other biological specimens (e.g., rodents, small primates, plants, etc.). The centrifuge contains two 25' x 8' x 8' (200 ft^2) rooms, each gimbal-mounted to allow rotation to maintain the orientation of the Gz resultant through the floor of each room during rotation. The rooms may be placed at radii from 13 to 22' to enable experimenters to explore interactions between rotation rate and radius on biological functions. One room can be configured as a human habitat, and the second as a laboratory habitat with a specimen housing room. The habitats are gimbal mounted, so that they can be connected by a passageway to enable human occupants (subjects or investigators conducting research) to move from one habitat to the other while the centrifuge is in operation. This facility is expected to yield important information about adaptation to long-term exposure to altered gravity.

The human habitat accommodates up to for individual sleep chambers positioned along its rear wall. A restroom/shower is located at one end of the habitat. The central area is configured as a group area. Each habitat is equipped with access to a radial passage connecting the habitat to the centrifuge hub. A motorized delivery system will transport all supplies to and from the centrifuge without interrupting rotation. Video monitoring of subjects is available. During experiments, human occupants have intercom access to experiment support personnel. While studies are in progress, PI staff, engineers, and facility support personnel monitor subjects from an experiment operation control center adjacent to the centrifuge. Experiment data can be downloaded through slip rings in real-time or off-line. Medical monitors are available on call, 24 hrsday.

For details regarding scientific capabilities of this device, contact the Gravitational Research Branch Chief at Ames Research Center at 650-604-5471. For technical details and scheduling information, contact the Facility Utilization Office Manager at Ames Research Center. Telephone: 650-604-6483.

5.1.3 Slow Rotation Test Facility

The slow rotation test facility was developed at Brandeis University to aid in the study of human behavioral and physiological responses to both predictable and aberrant force vectors generated by a rotating environment. The forces experienced under these conditions are very similar to those encountered in space vehicles that rotate to create artificial gravity.

The slow rotation test device is 22 feet in diameter and has a net weight in excess of seven tons. It is driven by a linear induction motor drive designed specifically for this application which has the capability of developing a constant torque of 2,350 ft-lbs. The drive can produce a gravitoinertial force in excess of 4g within the room for a 6,000 pound payload. By means of preprogrammed velocity profiles, the motor drive system can accurately control the rate of speed of the device in either direction over the entire 0 to 35 rpm speed range in increments as small as 1 degree per second squared to ten degrees per second squared increments; constant velocity can be maintained to within A .001 percent. Over the entire speed range, z-axis vibration has been measured at <0.001g. The room can also sinusoidally oscillate over a wide range of frequencies.

The slow rotation room can accommodate a wide variety of test devices with onboard power for devices requiring either 110 VAC, single phase or 220 VAC, or three phase.

For further information, contact Dr. James Lackner at Brandeis University. Telephone: 617-736-2033.

5.1.4 Parabolic Flights: The KC-135 “Zero-G” Aircraft

This aircraft, a specially modified version of a Boeing 707, can generate 20- to 30-second periods of microgravity and various levels and periods of hypergravity. This platform can be used to test and validate experimental equipment and new devices to ensure that they will operate properly in varying gravitational fields. Furthermore, since multiple parabolas can be flown, it is also possible to conduct actual experimental studies.

For further information, contact Todd Schlegel, M.D. at the NASA Johnson Space Center. Telephone: 281-483-9643.

5.1.5 Non-Human Hypergravity Facilities

The NASA Ames Research Center has a suite of hypergravity facilities capable of supporting studies using non-human subjects and human and/or non-human tissues in addition to those listed above. These facilities include:

- Chronic Hyper-Gravity Exposure (24’ Diameter) Centrifuge
- International Space Station Test-Bed (8’ Diameter) Centrifuge

The Chronic Hyper-Gravity Exposure (24’ Diameter) Centrifuge is designed to create hypergravity conditions up to 4.15g for small animal (such as rats, guinea pigs, rabbits, or primates) and plant research. The centrifuge has 10 radial arms and carries up to a total of 20 large, opaque, ventilated enclosures for holding animals and equipment. These enclosures can be located at different radii (variable from 4-12 ft at 6" intervals) to produce gravitational forces of up to four times Earth gravity on the floor of the enclosure. Three additional, smaller enclosures are available near the axis of rotation of the centrifuge, and eight stationary enclosures are available within the centrifuge rotunda to provide appropriate rotation and vivarium controls. Onboard water and food dispensing systems permit continuous studies. Slip rings provide in-cage TV monitoring and instrumentation capability. Hypergravity exposures are chronic (from days to months) with two half-hour stops per week for feeding and change of bedding.

For details regarding scientific capabilities of this device, contact the Chronic Hyper-Gravity Exposure (24’ Diameter) Centrifuge Science Director at Ames Research Center, at 650-604-4818. For technical and scheduling information, contact the Facility Utilization Office Manager at Ames Research Center. Telephone: 650-604-6483.

The International Space Station Test-Bed (8’ Diameter) Centrifuge was primarily designed for rodent studies, but also enables experiments in all habitats that will be used in the International Space Station. Experiments may be performed on plants or animals (e.g., rodents, small aquatics, insects, or cell cultures).

Biological studies may be performed on 10 animal enclosures (1 per radial arm), with maximum hypergravity exposures of up to 10 g’s at 85 rpm for periods of time from days to months, with two half-hour stops per week for feeding and change of bedding.

For details regarding scientific capabilities of this device, contact the International Space Station Test-Bed (8' Diameter) Centrifuge Science Director at Ames Research Center at 650-604-3943. For technical details and scheduling information, contact the Facility Utilization Office Manager at Ames Research Center. Telephone: 650-604-6483.

5.1.6 The Biocomputation Center

The Biocomputation Center at the NASA Ames Research Center is dedicated to computer-based three-dimensional (3-D) visualization of cells, tissues, and organs, to mathematically-based modeling, and to 3-D simulations of the functioning of living systems from the sub-cellular and molecular to the organismal level. The emphasis is on teams of broadly based, inter-disciplinary investigators and on a union between computational, theoretical, and experimental research. Using state-of-the-art computational hardware and customized software, the Biocomputation Center facilitates the integration of life sciences experimental research with computational approaches to aid understanding. The basic premise is that greater knowledge of how a cell, tissue, organ, or system is organized can be achieved by computer-based imaging of structural features in 3-D.

High quality images are digitized directly from a Zeiss 902 transmission electron microscope and electronically transferred to a graphics workstation for enhancement and 3-D reconstruction. Biological simulations are based on accurate 3-D reconstruction data and known physiology. The algorithm is a fully implicit, finite volume technique. The finite volume analysis method has potential as a new, general purpose compartmental model. New interactive 3-D abstract simulation based on a simple 2-D model includes the ability to interactively rotate, translate, and scale graphical representations while incorporating the real system's physiological characteristics. Information from 3-D reconstructions and mathematical models can be used to generate dynamic, symbolic computer simulations. Symbolic computer simulations of living systems can be viewed in a virtual reality environment to provide insights that may not be obtainable by traditional methods.

For details regarding scientific capabilities of this center, contact the Biocomputation Center Science Director at Ames Research Center at 650-604-4808. For technical details and scheduling information, contact the Facility Utilization Office Manager at Ames Research Center. Telephone: 650-604-6483.

5.1.7 Ground-Based Bed Rest Research Facility

The NASA Ames Research Center Bed Rest Research Facility is a 4100 ft^2 facility used to conduct studies of physiological responses of humans exposed to the bed-rest simulation that produces many of the physiological changes seen in space flight. Human subjects may be maintained comfortably for prolonged periods in either supine or 6° head-down bed-rest. During and following the bed-rest exposure, experimenters may conduct physiological studies of a variety of disciplines (e.g., endocrine, metabolic, and cardiovascular adaptations, musculoskeletal changes, exercise effectiveness, etc.).

Up to twelve subjects can live comfortably in this non-hospital environment for weeks or months, with all living requirements provided. The facility contains separate but readily accessible subject-living and test-administrative areas. It provides a highly controlled environment (temperature, light intensity, and photoperiod are automatically controlled) and is suitable for research on ambulatory or bed-rested subjects. A horizontal shower is used for test subjects who must remain supine. Two bedrooms are sound-proofed and have adjoining bathrooms, making them ideal for either isolation or group interaction studies. A dumbwaiter is used to transport biological specimens (e.g., blood and urine samples) to a clinical laboratory on the floor above for processing. Biomedical data can be transmitted by telemetry or hard wire from the subject's bed to a central data station for monitoring and recording. All meals are prepared in an integral modern kitchen, and thus experiment dietary requirements may be strictly controlled. A nutritionist is responsible for planning and preparing all meals. Ambulatory subjects eat and relax in a central lounge/recreation/dining area.

Test areas contain a variety of physiological and exercise test equipment. In addition to medical monitoring equipment, the facility provides a lower-body negative pressure device, upright and supine bicycle ergometers, an upright treadmill, isokinetic exercise devices, and a tilt table to test orthostatic tolerance. Investigators can also bring additional experiment-specific equipment. For provocative testing of bed-rest de-conditioned subjects using hypergravity or vestibular testing, near-by human-rated facilities at ARC can be used in conjunction with other facilities described in this section located at ARC.

For details regarding scientific capabilities of the facility, contact the facility Science Director at Ames Research Center at 650-604-5471. For technical details and scheduling information, contact the Facility Utilization Office Manager at Ames Research Center. Telephone: 650-604-6483.

5.1.8 Ground-Based Radiation Accelerator Facilities

NASA has signed Memoranda of Agreement (MOA) with two ground-based laboratories where energetic beams of protons and high-energy heavy ions are available; in particular, proton beams at the **Loma Linda University Medical Center** (protons with energies between 70 and 250 MeV) and the Alternating Gradient Synchrotron (AGS) at **Brookhaven National Laboratory** (beams of iron and other heavy nuclei, with energies as low as 600 MeV/nucleon, up to 10 GeV/nucleon). Delivery of beam time at the Brookhaven facility has been directly funded by a contract between NASA and Brookhaven, and similar arrangements are intended for use of the beam time at Loma Linda University Medical Center.

Brookhaven National Laboratory

The AGS machine is a US Department of Energy (DOE) facility that is funded by the DOE primarily for research in high energy particle and nuclear physics. Brookhaven is allowed by DOE to provide additional AGS beam time to other scientific users of the machine, as long as operating funds are provided by the sponsor of such proposed work. Use of the Brookhaven facilities requires a separate proposal, which is reviewed by a laboratory-appointed panel and is scheduled in accordance with available beam time and other laboratory resources. Once experiments are approved, they are required to satisfy the normal process of preparation for running at the AGS, which includes familiarization with AGS rules and policies (safety being the paramount consideration among these), and registration with the laboratory as a guest scientist.

User facilities have been developed at Brookhaven for radiation biology research, including cell cultures and small animals. These include the shielding cave containing the beam, the biological experiment station, and laboratory space and animal facilities in the Brookhaven Medical Department. A 10-foot long optical bench for sample exposures is available in the cave, as well as beam handling, sample changing, and dosimetry instrumentation. The biological experiment station contains one area for cell culture equipped with a laminar flow hood and incubator, one short-term animal holding facility, and one area for physics/run-control use. In addition, laboratory space and access to animal facilities accredited by the Association for Assessment and Accreditation of Laboratory Animal Care, are available in the Medical Department subject to standard use charges. Brookhaven also has on-site housing accommodation for users (dormitory and apartment-style units).

Iron (^{56}Fe) beams at 600 MeV/nucleon and at 1 GeV/nucleon have been used for experiments to date; investigators who need to use other beams or energies should contact the Brookhaven liaison scientists listed below. Normally, circular beam spots are provided, with diameters up to 10 cm, and center-to-edge uniformity between 10 percent and 20 percent (depending on dose rate -- high dose rate beams are less uniform than low dose rate beams). Dose rates have been measured up to 11 Gy/min. Investigators currently funded by the NASA program participate in research using these beams, and coordination of beam use with these investigators and institutions is actively encouraged. In particular, a physics and dosimetry group is available for investigators requiring their assistance.

For further information regarding Brookhaven National Laboratory, contact Dr. Marcelo Vazquez (e-mail: vazquez@image.bio.bnl.gov), Dr. Betsy Sutherland (e-mail: betsy@image.bio.bnl.gov), or Dr. Phil Pile (e-mail: pile@bnldag.ags.bnl.gov). The address is Brookhaven National Laboratory, PO Box 5000, Upton, NY 11973-5000.

Loma Linda University

Loma Linda University operates a facility for therapy of cancer and other diseases using accelerated protons from a synchrotron which is located within the medical center. Associated with the synchrotron are treatment rooms and all clinical services relevant to radiation therapy. Also associated with the synchrotron are an experimental area ("research room") which can receive a proton beam and an adjacent staging laboratory from which the accelerator can be operated and experiments may be configured prior to irradiation. Close to the accelerators is the new Chan Shun Pavilion, a wing of a research building whose first floor has been designated for a radiobiology research program with capabilities for modern cellular, molecular, and *in vivo* biology studies. Included in this structure is a laboratory dedicated for the use of visiting scientists whose research requires access to proton beams.

The basic beam line was designed to bring protons from 40 to 250 MeV to the research room for experimental work while not interfering with patient treatments. The beam line will provide for flexible delivery of proton beams at doses, dose rates, energies, field sizes, and field uniformities that are adequate for many biology, physics, and materials science experiments. A Co-60 irradiator has been installed to provide gamma rays for control experiments.

For further information the Loma Linda University Medical Center, contact Dr. Gregory A. Nelson (e-mail: gnelson@lluci.llu.edu), Director, Radiobiology Program, Loma Linda University Cancer Institute, 11360 Mt. View Avenue, Hartford Bldg, Ste. B, Loma Linda, CA 92354. Telephone: 909-478-8366.

5.1.9 Space Human Factors Facilities

The Graphics Research and Analysis Facility (GRAF) and the Anthropometry and Biomechanics Facility (ABF) are managed by the Flight Crew Support Division at the Johnson Space Center. The **Graphics Research and Analysis Facility** has systems for computer modeling of humans and environments. It provides anthropometric, kinematic, and visibility analyses of humans working in 1-g, zero-g, or partial-g. GRAF has access to strength and size databases and a physically-based system for computer modeling illumination for camera/eye vision with the ability to empirically collect luminance and illuminance data. It also has a large collection of models of the Shuttle, Spacelab, Spacehab, and ISS modules in which to perform this integrated analysis of humans working in space both EVA and IVA.

The **Anthropometry and Biomechanics Facility** collects and analyzes strength, force, and motion data, in the Weightless Environment Test Facility (WETF) and in the KC-135 zero-g aircraft. Equipment includes Lido dynamometers, Ariel Motion Analysis Systems, and waterproofed and KC-135-qualified force plates. The ABF personnel are experienced in collecting data from suited subjects, as well as on the Precision Air Bearing Floor.

For further information, please contact Dr. Francis Mount at the Johnson Space Center. Telephone: 281-483-3723.

5.2 Research Facilities in Germany

5.2.1 Microgravity User Support Center

The DLR **Microgravity User Support Center** (MUSC) is the German user support center for research under space conditions. The MUSC is equipped with laboratory infrastructure, simulation facilities, experiment control rooms, user rooms for science monitoring and data evaluation, a user information area with a microgravity library, and the information system ARIADNE. Additional equipment and laboratories are located in the Institute of Aerospace Medicine. The Institute of Aerospace Medicine offers a unique infrastructure for applications in an international scope of space biology and human physiology research, providing support for ground-based research, payloads, and Space Station utilization for interagency investigations in cell and molecular biology, systems biology, plant biology, botany, and zoology.

For 0g simulations, hypergravity experiments, and extended ground-based research, the following infrastructure and facilities can be utilized for integrated investigations in the above mentioned fields of research:

- Fast rotating clinostats with online microscopic observation
- Cuvette clinostats
- STATEX incubator for small petri dishes with reference centrifuge
- BIOLABOR double rack
- Slow Rotating Centrifuge Microscope (NiZeMi lab model, up to 5g)
- Cultivation chambers for Biorack containers Type I and NiZeMi
- Several centrifuges including large centrifuge
- Large-scale Magnetic Resonance device for biological and biomedical investigations (imaging, microscopy, and spectroscopy)
- Tilting microscope
- Data and image processing capabilities
- Computer-based fluorescence microscopy (Zeiss Attofluar)

For further information regarding the Microgravity User Support Center, contact Dr. Marianne Schuber (e-mail: Marianne.Schuber@dlr.de), German Aerospace Center (DLR), Institute for Aerospace Medicine, Linder Höhe 45, D-51147 Köln, Germany. Telephone: (49)-2203-601-3523.

5.3 Research Facilities in France

5.3.1 Clinical Research Facility

The **Clinical Research Facility** (CRF) is a $1000m^2$ (10,700 square feet) multi-purpose facility located within the Toulouse Rangueil Hospital. It is operated by MEDES (Institut de Médecine et Physiologie Spatiales), a subsidiary of the French Space Agency, Toulouse Hospital, the French Atomic Energy Commission, and several universities and research centers.

The CRF has been designed to host most of the ground-based clinical or human factors experimental research necessary to conduct space research such as:

- simulation of effects of the space environment (bed rest, confinement, circadian rhythms, etc.)
- performance of experiment verification tests or control experiments
- testing of equipment or procedures
- medical screening and check-up for healthy volunteers
- training courses of students and hosting of Ph.D. students

CRF has access to the biomedical facilities of a high standard hospital (NMR, CT scan, biological analyses). Its internal equipment includes the main required devices to test and monitor specific physiological functions (LBNP, tilt table, rotating chair) and to handle biological samples.

It allows monitoring of the main environmental parameters or parameters linked to the subject, such as diet, activity (24 hour video monitoring), temperature (2 - 25°C ± 0.5°C), acoustics (isolation of 60dB from external environment, background less than 35dB), and lighting (natural/artificial ranging from 0 to 500 Lux).

CRF capacity ranges from:

- 4 beds for strictly controlled sleep or alertness studies, enabling blood sampling and physiological recordings without disturbing the patient
- 6 beds for strictly controlled sleep or alertness studies
- up to 26 beds for miscellaneous tests

CRF is served by highly skilled professionals matching the requirements of good clinical and good laboratory practices. Services will be strictly tailored to the needs of the investigators. They can be limited to a simple logistics accommodation, hosting of researchers, and the coordination of international multicentric studies.

For further information, contact Dr. Anne Pavy le Traon (e-mail: Anne.Pavy-Le.Traon@cst.cnes.fr), Clinique de l'Espace, 1 avenue Jean Poulhes, 31054 Toulouse Cedex, France. Telephone: 33-62-17-49-50. Fax: 33-62-17-49-51.

5.3.2 Parabolic Flights: Airbus A 300

Parabolic flights are of interest for the scientific users, industry, and space agencies due to the reduced costs, the operational feasibility, and the possibilities to receive technical teams which design space experiments. Parabolic flights are used primarily to perform life sciences or physical sciences research in microgravity conditions, research in technology, and to test ergonomy, security, or procedures.

Two types of campaigns can be organized:

- The standard campaigns: Three flights of 30 parabolas each (1 flight per day). About 15 different experiments can be accommodated, and 35 to 40 people can participate.
- Specific campaigns during which a unique user can choose the number of flights, their duration, and their profile. This approach can be organized from Bordeaux, France or from anywhere in the world.

The cabin dimensions are 20 m long x 5m wide x 2.40 m high. The total volume is $300m^3$. The cabin pressure is 300 mb and the inside temperature is 20°C.

The parabolic flight campaigns are organized by NOVESPACE, which is a CNES subsidiary.

For further information, please contact Monsieur Denis Thierion (e-mail: denis.thierion@cst.cnes.fr), CNES, 18 avenue Edouard Belin, 31055 Toulouse Cedex, France. Telephone: 33-61-27-32-48. Fax: 33-61-28-21-65.

5.3.3 Center of Assistance for the Development of Microgravity Operations in Space (CADMOS)

The **CADMOS**, located at the Toulouse Space Center, was created in 1991 to provide technical and operational support to scientific users in the field of microgravity sciences. It includes various laboratories and a control center which are described below.

Technical Support: The CADMOS provides means to prepare experiments in the field of physiology and biology. The CADMOS is equipped with laboratory areas including ground model facilities and test benches. The following instruments are currently available:

- **Physiology**
  - PHYSIOLAB (cardiovascular physiology)
  - COGNILAB (sensorimotor physiology)

- **Biology**
  - FERTILE (amphibian development)
  - IBIS (cellular biology, development)

These instruments can be used for ground-based studies and for pre- and post-flight investigations. A user information area is also implemented with microgravity experiments and facilities documentation, vehicle information documentation, an archive, and a user database.

Operational Support: The CADMOS control center provides means for remote control of space experiments. This control center has already been used during several missions, including Shuttle flights and Mir missions. Information from space is made available to the scientists on the ground via audio and video links, as well as telemetry. Telescience capabilities can also be provided.

The CADMOS is equipped with a specific control room, a private video-conference room, user rooms for data monitoring and evaluation, technical premises, and reception and meeting rooms. These technical and operational supports are located in the same building.

For further information, please contact Mr. Alain Desroche, CNES/CT/ED/MV/CA, Bpi 2221, 18 avenue Edouard Belin, F-31401 Toulouse Cedex 4, France. Telephone: 33-5-6128-2623. Fax: 33-5-6128-2165.

5.4 Research Facilities in Japan

5.4.1 Ground-Based Accelerator Facility (HIMAC)

The Heavy Ion Medical Accelerator at Chiba (HIMAC) is a synchrotron facility in the National Institute for Radiological Sciences (NIRS), Chiba, Japan, dedicated for medical therapy and related research. The NIRS also provides research opportunities for domestic and international researchers to conduct radiological, biological, and physical investigations through an HIMAC annual solicitation. The facility is used for medical therapy during the day and is open for researchers at night. The HIMAC has two types of research ports: the Biology Port and the Physics Port.

The synchrotron generates accelerated particles of various nuclei with a cyclic period of 3.3 sec. The flux ranges from 100 to 10^7 particles/spill. The diameter of the beam spot ranges from 10 mm to 20 mm in the Physics Port, and 200 mm in the Biology Port. In the Physics Port, dose and LET should be evaluated separately because the counts are only essential in physical experiments. In the Biology Port, the dose and LET are evaluated by instruments installed at the port (ion chamber along with calculation for dose, and LET). The calculated dose and LET are provided to users in each irradiation by operators.

Carbon ions of 290 MeV/nucleon at 1.8×10^9 particles/spill are currently available during weekdays for medical therapy. Carbon ions are available for researchers conducting physics or biology experiments during weeknights. If the experiments require ions other than carbon ions, the experiments must conducted during the weekend (Friday night to Sunday morning).

The following are the currently available beams:

Physics Ports:

Particle	Energy Range (MeV/nucleon)	Particle fluence (particles/spill)	
		Port I	Port II
He	6 - 230	2.0×10^{11}	1.2×10^{10}
C	6 - 430		
N, O	6 - 400		
Ne	6 - 600		
Si	6 - 800		
Ar	6 - 390		2.4×10^8

Biology Port:

Particle	Energy Range (MeV/nucleon)	Particle fluence (particles/spill):
He	6 - 230	1.2×10^{10}
C	6 - 430	
N, O	6 - 400	
Ne	6 - 600	
Si	6 - 600	
Ar	6 - 500	2.7×10^{8}

Other available ions, but under testing:
P (160, 230), Fe (500), Xe (290, 500), Kr (500)

Particle fluence (pps):

Physics Port I	2.0×10^{11} (He) – 1.0×10^{11} (Ar)
Physics Port II	1.2×10^{10} (He) – $2.4\text{x } 10^{8}$ (Ar)
Biology Port	1.2×10^{10} (He) – $2.7\ 10^{8}$ (Ar)

Detailed information on HIMAC and its utilization can be obtained from the following point of contact. Applications must be submitted well in advance.

Kazunobu Fujitaka (e-mail: fujitaka@nirs.go.jp), National Institute of Radiological Sciences, 4-9-1 Anagawa, Inage, Chiba 263-8555, Japan. Telephone: +81-43-206-3230. Fax:+81-43-251-4836.

Ms.Yuka Machida (e-mail: yuka_m@nirs.go.jp), National Institute of Radiological Sciences, 4-9-1 Anagawa, Inage, Chiba 263-8555, Japan. Telephone: Tel: +81-43-206-3230. Fax:+81-43-251-4836.

6.0 International Application Forms and Instructions for Proposal Preparation

This section contains the general instructions for proposal preparation and the specific forms required by proposers responding to agency solicitations for flight experiments in the space life sciences for 1998. The forms at the end of this section include the following:

Form A	Solicited Proposal Application
Form B	Proposal Abstract
Form C	Space-Flight Experiment Preliminary Description
Form D	Biographical Sketch
Form E	Other Support
Form F	Detailed Budget, First Year
Form G	Detailed Budget, Entire Project Period
Form H	Checklist for Proposers

Instructions for Proposal Preparation

The information contained in these instructions is specific to the research solicitations and repeats or supplements the general guidance provided in agency specific announcements.

With the exception of Forms E, F, and G, **all** proposals should include one copy of each of the Forms provided in this Section as part of the complete submission. Proposals submitted to NASA and CSA should include Forms E, F, and G. Proposals submitted to the ESA solicitation which include co-investigators from the U.S. or Canada should include Forms E, F, and G completed with respect to the involvement of these co-investigators.

The proposal must include the following material, in this order:

(1) Cover Page: Solicited Proposal Application (Form A)*
(2) Proposal Abstract (Form B)
(3) Proposal Title Page, with Notice on Restriction on Use and Disclosure of Proposal Information, if any
(4) Project Description
(5) Space Flight Experiment Preliminary Description (Form C)
(6) Management Approach
(7) Letter of Assurance of Foreign Support (if applicable)
(8) Biographical Sketch (Form D)
(9) Other Support (Form E)
(10) Facilities and Equipment
(11) Supporting Budgetary Information (if applicable)
(12) Special Matters (specific information on animal or human subjects protocol approval required, if applicable)*
(13) Detailed Budget, 12 Month (Form F, if applicable)

(14) Detailed Budget, Entire Project Period (Form G, if applicable)
(15) Checklist for Proposers (Form H)
(16) Appendices, if any
(17) Computer diskette (3.5 inch, Macintosh or PC format) containing an electronic copy of the principal investigator's name, address, telephone and fax numbers, e-mail address, and the complete project title and abstract as provided on Form B

* One signed original required

The Project Description Section is limited to 25 pages. Any pages in this section beyond 25 will not be reviewed. There is no specific page limitation on other sections of submitted proposals. However, every effort should be made to keep proposals as brief as possible. The name of the Principal Investigator should appear in the upper right hand corner of each page of the proposal, except on the Forms in this Document where special places are provided for this information. Note that the proposal <u>must</u> specify the period of performance for the work described; periods of performance may be for any duration up to three (3) years but should be suitable for the project proposed.

6.1 Cover Page: Solicited Proposal Application (Form A)

All of the information requested on Form A must be provided, and one original signature version of this form should be submitted.

For Item (7) on this form, <u>new</u> means that a proposal for this project has not been submitted to the soliciting agency in 1996 or 1997, <u>renewal</u> means that this proposal is for the continuation of an already funded task beyond the term of the funded proposal, and <u>revised</u> means that this proposal represents a revision of a proposal submitted to the soliciting agency in 1996 or 1997, but not funded. A proposal previously submitted but not funded should be termed revised even if the original principal investigator has changed for 1998. Renewal and revised applications should contain special material described in the Project Description section below.

Note that items (9) and (10) on Form A require assurance of compliance with human subject and/or animal care provisions of agency and governmental regulations. Applicants should refer to the agency solicitation for specific instructions in this area.

6.2 Proposal Abstract (Form B)

The information requested on this form is essential to the review of the proposal. It determines how the application will be evaluated and which agency manager(s) will receive the final review materials for possible inclusion in one of the research programs of the agency.

6.3 Proposal Title Page

The title page should contain the project title, name and address of the submitting institution, the name, address and telephone number of the principal investigator, and the names and institutions of any co-investigators. Proposers should refer to agency specific solicitations for instructions regarding additional information which should be included on the title page.

6.4 Project Description

The length of the Project Description section of the proposal should not exceed 25 pages using regular (12 point) type. Any pages beyond 25 will not be reviewed. The proposal should contain sufficient detail to enable a reviewer to make informed judgments about the overall merit of the proposed research and about the probability that the investigators will be able to accomplish their stated objectives with the resources requested and with their own resources. The proposal should indicate clearly the relationship between the proposed work and the research emphases defined in the agency specific solicitations.

Renewal applications (for competing renewal of currently funded activity) must include a progress report as an Appendix to the proposal, and should refer to this Appendix appropriately throughout the Project Description section.

Revised applications (revisions of 1996 or 1997 submissions) must include, as part of the Project Description section, an **Introduction** that contains responses to the criticisms in the previous critique. Applicants should highlight the changes they have made in their research plan by appropriate bracketing, indenting, or changing of typography. Clearly present any work done since the prior version was submitted. Note that revised applications that do not address the criticisms in the previous critique and do not include substantial revisions will be considered unresponsive and will be returned without review.

6.5 Space Flight Experiment Supplementary Application Information (Form C)

All applicants proposing space flight research must provide the information requested on Form C. The information on this form is essential for the evaluation of the feasibility of performing the proposed study. Before filling out this form, applicants should read Section 2.0 of this document carefully and make certain that they understand the constraints that are associated with flight experiments.

6.6 Management Approach

Each proposal must specify a single principal investigator who is responsible for carrying out the proposed project and coordinating the work of other personnel involved in the project. In proposals that designate several senior professionals as key participants in the research project, the management approach section should define the roles and responsibilities of each participant, and note the proportion of each individual's time to be devoted to the proposed research activity. The proposal must clearly and unambiguously state whether these key personnel have reviewed the proposal and endorsed their participation.

6.7 Letter of Assurance of Foreign Support

Applications submitted to the NASA Research Announcement by organizations outside of the U.S., and that are not entities of the space agencies of ESA, CSA, or NASDA, must include a written endorsement from the respective agency or funding/sponsoring institution (see Appendix A, Section VIII, Part C of the NASA Research Announcement 98-HEDS-02 for details).

6.8 Biographical Sketch (Form D)

The Principal Investigator is responsible for direct supervision of the work and must participate in the conduct of the research regardless of whether or not compensation is received under the award. A short biographical sketch of the Principal Investigator that includes his or her current position title and educational background, a list of principal publications, and a description of any exceptional qualifications must be included. Use Form D to describe the research and professional experience of each professional staff member. Concluding with present position, list, in chronological order, previous employment, experience, and honors. Include present membership on any government public advisory committee. List, in chronological order, the titles, all authors, and complete references to all publications during the past three years and to representative earlier publications pertinent to this application. If the list of publications in the last three years exceeds two pages, select the most pertinent publications. Do not exceed two pages. Omit personal information which does not merit consideration in evaluation of the proposal. Provide similar biographical information on other senior professional personnel who will be directly associated with the project. Provide the names and titles of any other scientists and technical personnel associated substantially with the project in an advisory capacity. Universities should list the approximate number of students or other assistants, together with information as to their level of academic attainment. Any special industry-university cooperative arrangements should be described.

6.9 Other Support (Form E)

Use the format described in Form E to list other sources of research support for the proposed Principal Investigator and each of the proposed co-investigators. Please list all active support as well as any pending support.

6.10 Facilities and Equipment

Describe the available facilities and major items of equipment specially adapted or suited to the proposed project, and any additional major equipment that will be required.

Identify any government-owned facilities, industrial plant equipment, or special tooling that are proposed for use on the project. Provide evidence that such facilities or equipment will be made available if the applicant is successful in obtaining funding. Before requesting a major item of capital equipment, the proposer should determine if sharing or loan of equipment already within the organization is a feasible alternative to purchase. Where such arrangements cannot be made, the proposal should so state. The need for items that can be typically used for research and non-research purposes should be explained.

6.11 Special Matters

The Special Matters section must contain appropriate statements regarding human subject or animal care provisions. Proposers should refer to the agency specific solicitations for instructions on this section.

6.12 Detailed Budget, 12 Month (Form F) and
6.13 Detailed Budget,Entire Project Period (Form G)

Applicants responding to the NASA and CSA solicitations, whose organization is within these countries, are required to submit the information requested on Forms F and G. In addition, applicants to the ESA solicitation which include co-investigators from the U.S. or Canada should provide this information relative to the participation of these co-investigators.

Foreign proposals from organizations outside the U.S. and Canada which do not have a U.S. or Canadian co-investigator should not submit these forms.

6.14 Supporting Budgetary Information

Applicants responding to the NASA and CSA solicitations are required to submit this information. In addition, applicants to the ESA solicitation which include co-investigators from the U.S. or Canada should provide this information relative to the participation of these co-investigators.

This section must include information which supports the costs submitted in Forms F and G. In this solicitation, the terms "cost" and "budget" are used synonymously. Sufficient proposal cost detail and supporting information are required; funding amounts proposed with no explanation (e.g., Equipment: $1,000, or Labor: $6,000) may cause delays in evaluation and award. Generally, costs will be evaluated as to realism, reasonableness, allowability, and allocation. The budgetary forms define the desired detail, but each category should be explained in this section. Offerors should exercise prudent judgment in determining what to include in the proposal, as the amount of detail necessarily varies with the complexity of the proposal.

The following examples indicate the suggested method of preparing a cost breakdown:

Direct Labor - Labor costs should be segregated by titles or disciplines with estimated hours and rates for each. Estimates should include a basis of estimate such as currently paid rates or outstanding offers to prospective employees. This format allows the agency to assess cost reasonableness by various means including comparison to similar skills at other organizations.

Other Direct Costs - Please detail, explain, and substantiate other significant cost categories as described below:

a) Subcontracts: Describe the work to be contracted, estimated amount, recipient (if known), and the reason for subcontracting.
b) Consultants: Identify consultants to be used, why they are necessary, the time they will spend on the project, and the rates of pay (not to exceed the equivalent of the daily rate for Level IV of the Executive Schedule, exclusive of expenses and indirect costs).
c) Equipment: List separately. Explain the need for items costing more than $5,000 (or the equivalent in Canadian dollars). Describe basis for estimated cost. For proposals to NASA, General Purpose equipment is not allowable as a direct cost unless specifically approved by the NASA Grant Officer. Any equipment purchase requested to be made as a direct charge under this award must include the equipment description, how it will be used in the conduct of the basic research proposed, and why it cannot be purchased with indirect funds.
d) Supplies: Provide general categories of needed supplies, the method of acquisition, and estimated cost.
e) Travel: Describe the purpose of the proposed travel in relation to the grant and provide the basis of estimate, including information on destination and number of travelers where known.
f) Other: Enter the total of direct costs not covered by a) through e). Attach an itemized list explaining the need for each item and the basis for the estimate.

Indirect Costs - Indirect costs should be explained to an extent that will allow the agencies to understand the basis for the estimate.

6.15 Checklist for Proposers (Form H)

One copy of a completed version of this checklist should be attached to the transmittal letter.

6.16 Appendices, if any

Renewal applications (for competing renewal of currently funded activity) must include an appendix providing a Progress Report of the previously funded activity. This report should provide the beginning and ending dates for the period covered since the project was last reviewed competitively and provide a list of all personnel who have worked on the project during this period (including dates of service and percentages of their appointments devoted to the project). The report should also summarize the previous project's original goals and specific objectives and provide a succinct account of published and unpublished results indicating progress toward their achievement. Changes in these objectives during the course of the project and a rationale for these changes should be presented. The importance of the findings should be summarized and discussed. Finally, a list should be provided of the titles and complete references to all publications, manuscripts submitted or accepted for publication, patents, invention reports, and other printed materials that have resulted from the project since it was last competitively reviewed. Other appendices may be appropriate for particular proposals.

6.17 Computer Diskette

A diskette (3.5 inch, Macintosh or PC format) should contain an electronic copy of the Principal Investigator's name, address, telephone and fax numbers, e-mail address, and the complete Project Title and Abstract as provided on Form B.

The Required Application Forms

must be downloaded separately from

http://peer1.idi.usra.edu/peer_review/nra/98_HEDS_02.html